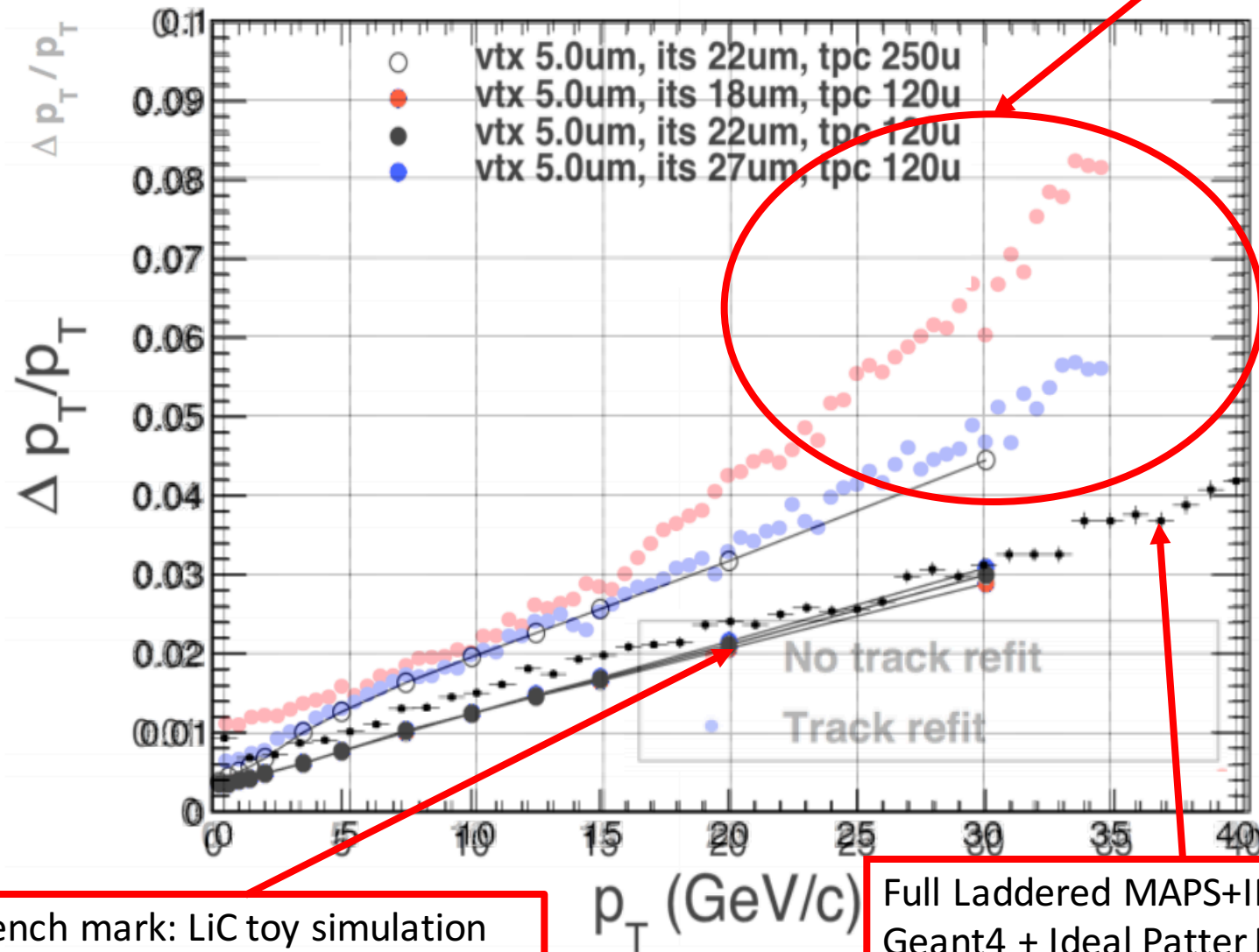# Update on Tracking Software

Christof Roland(MIT), Anthony Frawley(FSU),

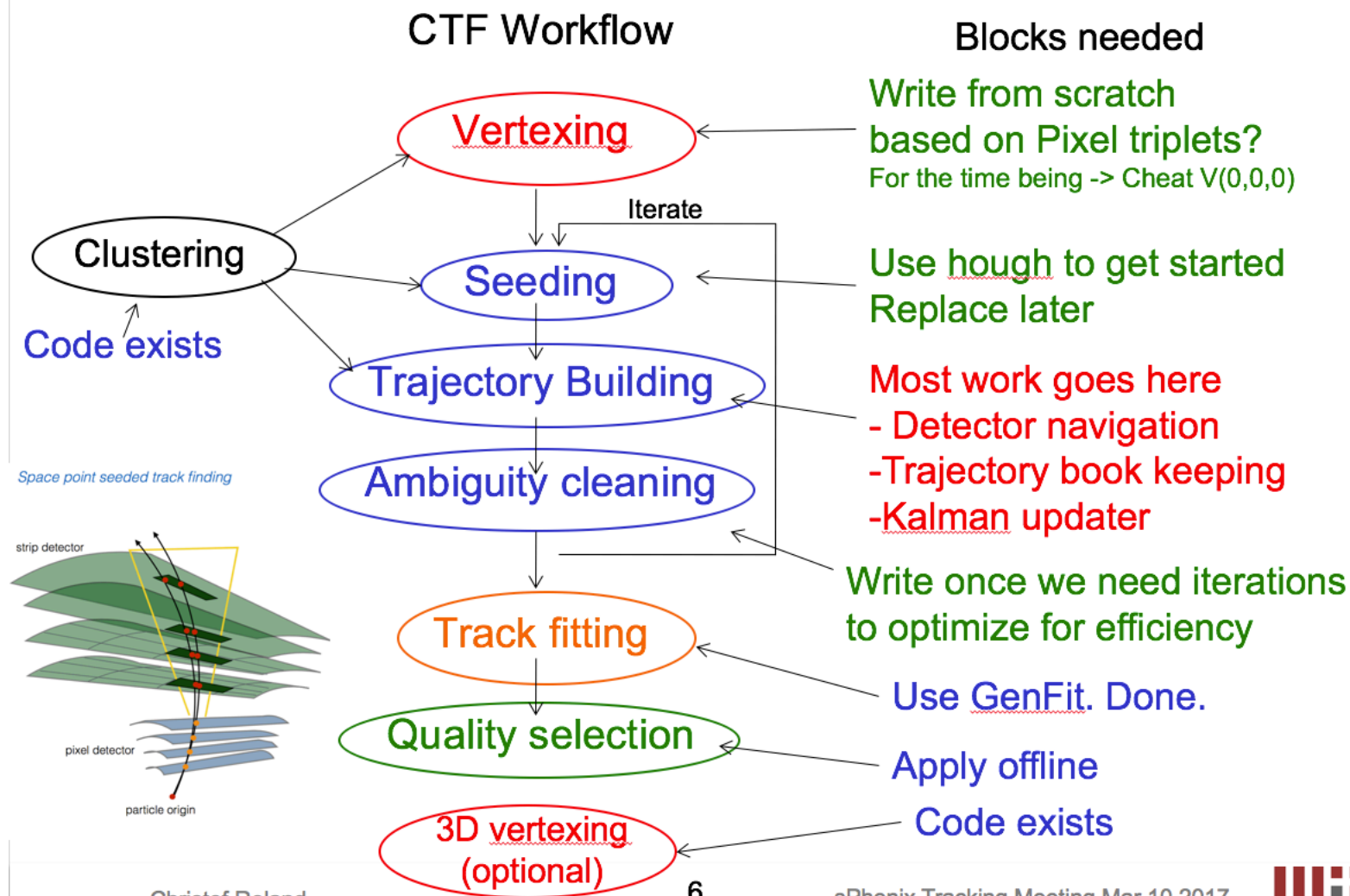Jin Huang(BNL), Haiwang Yu (NMSU)

New Pattern Recognition Needed

Momentum resolution much worse than benchmarks

Bench mark: LiC toy simulation by Christof Roland

Full Laddered MAPS+INTT+TPC Geant4 + Ideal Patter Recognition + Full Kalman fit (GenFit2)

Building blocks for a combinatorial track finder (CTF)

CTF Workflow

Blocks needed

Vertexing — Write from scratch based on Pixel triplets? For the time being -> Cheat V(0,0,0)

Clustering

Code exists

Iterate

Seeding — Use hough to get started Replace later

Trajectory Building — Most work goes here - Detector navigation -Trajectory book keeping -Kalman updater

Space point seeded track finding

Ambiguity cleaning

Write once we need iterations to optimize for efficiency

strip detector

pixel detector

particle origin

Track fitting — Use GenFit. Done.

Quality selection — Apply offline

3D vertexing (optional) — Code exists

Christof Roland

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sPhenix Tracking Meeting Mar 10 2017

MiT

Taskforce formed

- Tony and Christof organized a [taskforce](#) to beat it.
  - MAPS+INTT - Tony
  - TPC - Carlos, Veronica
  - GenFit - Haiwang
  - Seeding - Christof, Sourav, Haiwang
  - Trajectory Builder - Christof, Haiwang
  - Ambiguity resolution - Sanghoon
  - Track Quality selection - Veronica + Sourav
  - Performance evaluation - Sourav, Xiaolong
  - etc.

sPhenix Tracking Tasks

High Priority (Crucial for first implementation and MVTX Proposal)

Redesign hit and track structures - This is a basic building block of the project (Carlos, Haiwang)
- Minimize coordinate transformations, cache information
  - TPC coordinate map and cache (Carlos)
  - Silicon case (Tony)
- TVector operations?
- SvtxHit and SvtxTrack vs genfit::track and genfit::measurementOnPlane (Haiwang)
- Avoid duplication and parallel structures (Carlos)

Detector loop + hit containers - Efficient access and sorting of hits will determine performance
- Hits sorted by Layer
  - TPC hit/digit/cluster structure navigation (Carlos)
  - Silicon (MAPS + INTT) (Veronica)
  - Overlap treatment within Si layers (later)
- Direct access by Eta-Phi ranges
  - TPC coordinate map (Carlos)
  - Silicon (Veronica)
- Hit <-> detector plane association (generic container design for TPC + silicon, Haiwang + Carlos + Veronica)
- Alignment friendly implementation (keep in mind, hit needs to know which detector, Jin)
- Material budget per layer, active vs inactive detector components

GenFit - Key element to build trajectories (Haiwang)
- Turn Kalman Fitter into Filter for pattern recognition
- Isolate tools to calculate Chi2 increment for a given hit and TrajectoryState updates after adding a hit
- Provide easy to use getters
- Interface to material per layer (done, Jin)

TrajectoryBuilder class - Class to pull all elements together (Christof, Haiwang)
- Loop over seeds
- Track propagation
- Dynamic handling of track cloning and deletion
- Optimization of propagation strategy

   - Propagate each track to the end of the detector first vs propagating all tracks one layer at a time
   - Hit or track multiplicity may make caching more efficient in one case vs the other
- Track scoring (Sanghoon)
   - Decide if a trajectory needs to be kept or dropped based on holes in the track, chi2 etc.

Ambiguity resolution - Necessary to keep fake rate in check and to avoid duplication (Sanghoon)
- Check track overlaps based on shared hits
- Book keeping of hit usage. Unique hit <-> track association vs hit sharing?
- Releasing of hits from bad tracks

Important (Needed for performance tuning of first implementation)

Definition of final Track Quality selection(Veronica + Sourav)
- Identify track quality criteria to protect against fakes while keeping the efficiency high
- Study impact of track quality on parameter estimation

Cluster validation -> Make optimal use of the detector information to estimate hit positions and errors
- Fix ITT hit position from simulation (Tony)
- TPC clustering, drift parameterization (Carlos)
- Hit sharing + clustering (Sourav)
- Cluster position determination. Parameterizations? (Sourav)

Performance evaluation (Sourav, Xiaolong)
- Efficiencies, fake rates, parameter resolutions, pull distributions, biases etc.
- Preparation of efficiency, fake rate correction tables
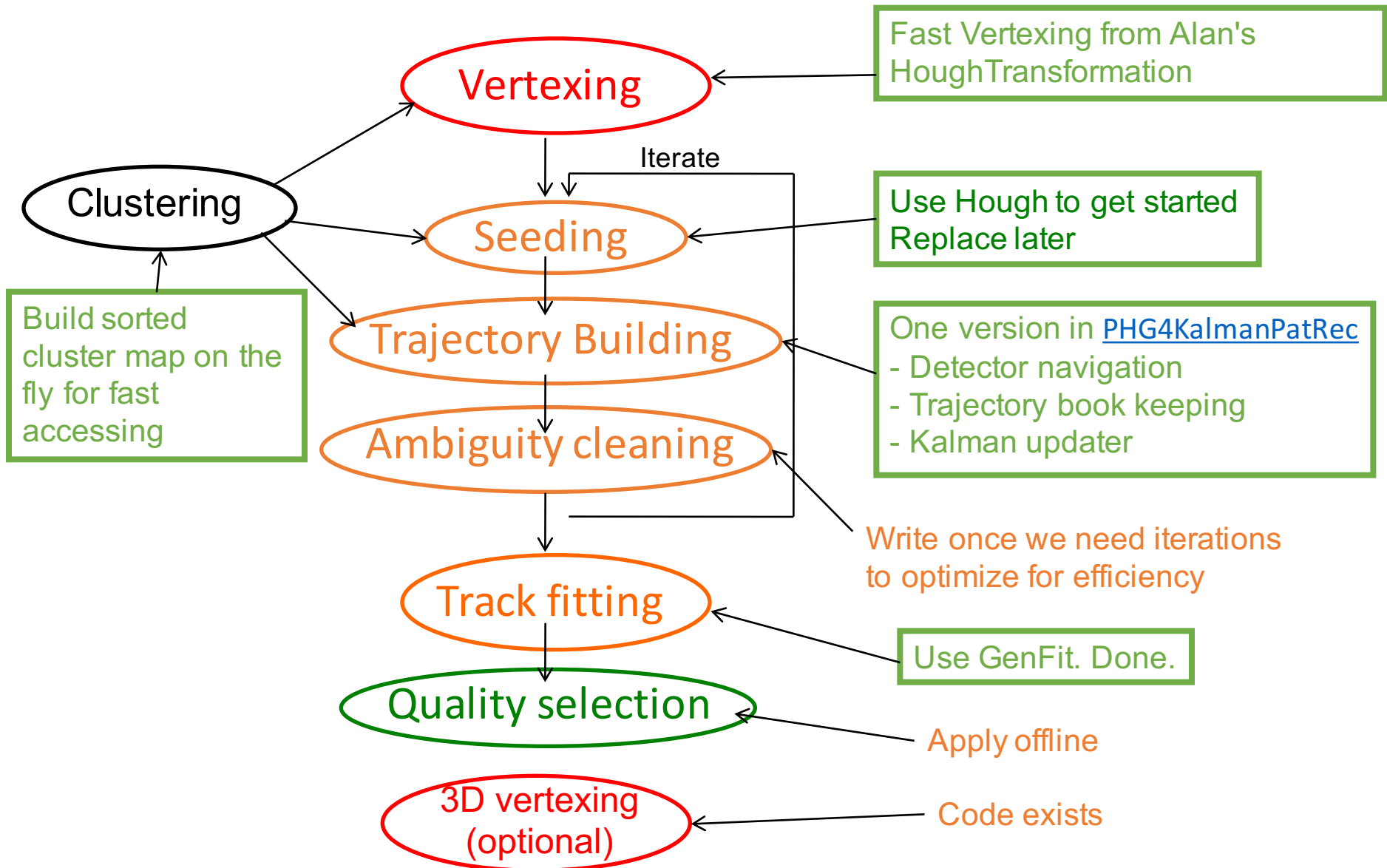- Higher level checks, J/Psi mass peaks, HF/b-jet observables
- CPU performance

Optimization of hough tracking for seeding (Sourav)
- Limiting PHG4HoughTransformTPC to the Si layers (0 - 7) works but gives shaky results

Progress

- MAPS and INTT charge sharing - Tony

- Deubgging ladder INTT clustering - Tony, Gaku, Chris

- Improvements on TPC simulation - Carlos, Veronica

- Seeding study using Alan's Hough - Christof, Sourav, Haiwang

- GenFit measurement updater - Haiwang

- Working in progress module: **PHG4KalmanPatRec** - Christof, Haiwang
  - Working well with low multiplicity events
  - Still needs tuning for central Hijing

CTF Workflow

Blocks needed

Vertexing

Fast Vertexing from Alan's HoughTransformation

Clustering

Iterate

Seeding

Use Hough to get started
Replace later

Build sorted cluster map on the fly for fast accessing

Trajectory Building

One version in PHG4KalmanPatRec
- Detector navigation
- Trajectory book keeping
- Kalman updater

Ambiguity cleaning

Write once we need iterations to optimize for efficiency

Track fitting

Use GenFit. Done.

Quality selection

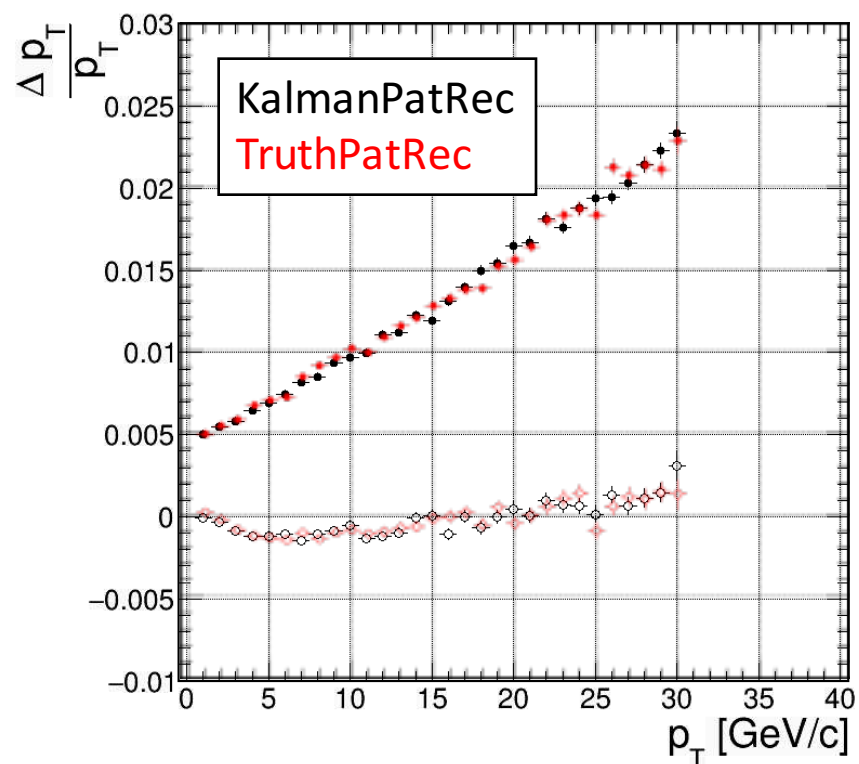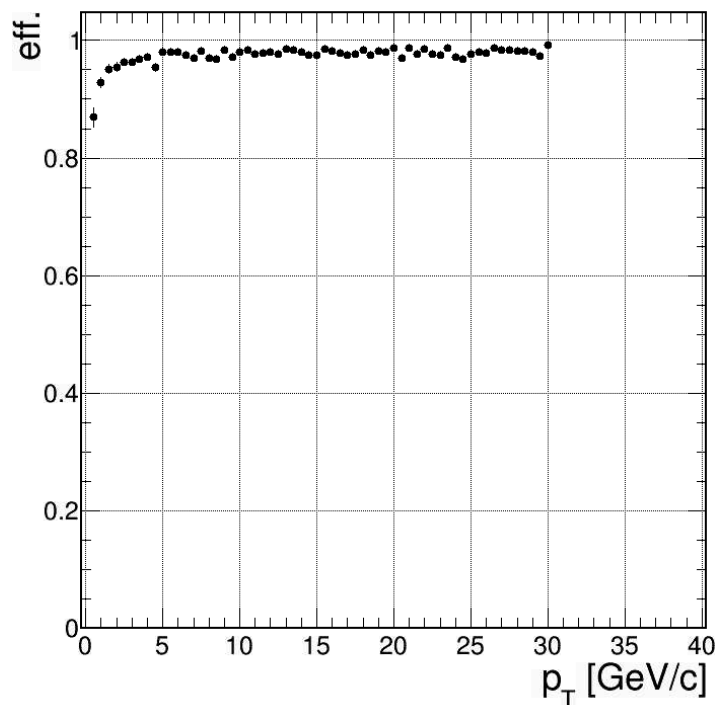Apply offline

3D vertexing (optional)

Code exists

Single particle test 2017-05-12

Configure:
- Ladder MAPS + INTT + Cylindrical TPC (nightly build)
- single pion
- 0.5 - 30 GeV, $-0.5 < \eta < 0.5$

Cuts:
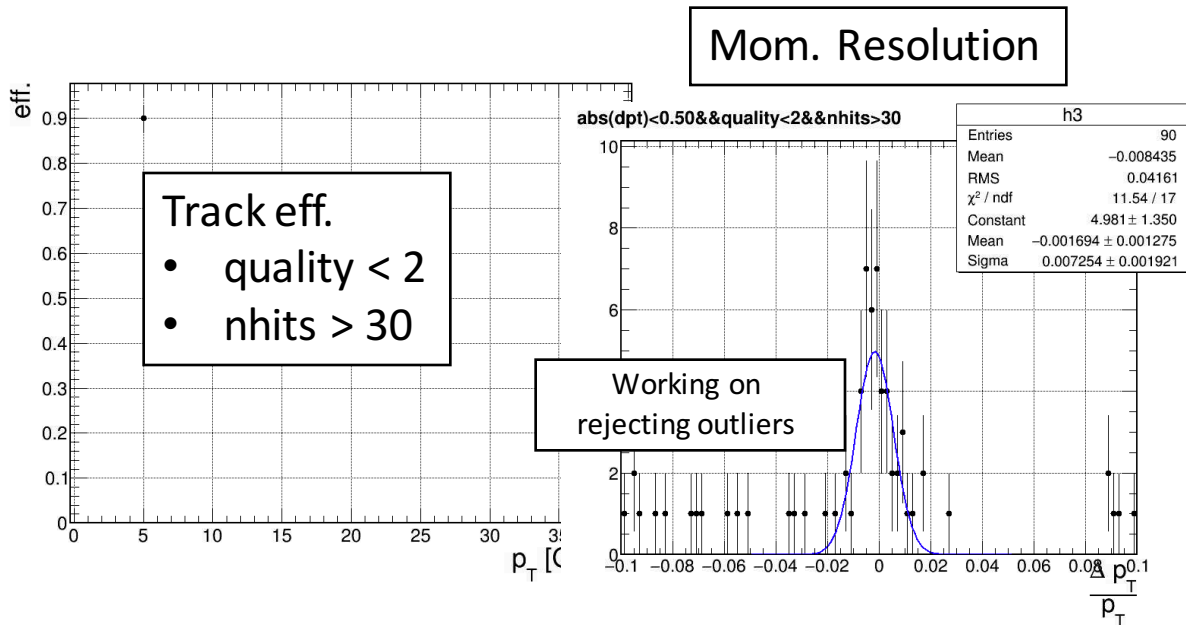- 6/8 seeding (MAPS + 5 TPC)
- Search Win: 5σ
- chi2 < 20

Configure:
- Ladder MAPS + INTT + Cylindrical TPC (nightly build)
- 100 pions embedded in central Hijing event
- pT = 5 GeV, $-0.5 < \eta < 0.5$

Cuts:
- 6/8 seeding (MAPS + 5 TPC)
- Search Win: 5σ
- chi2 < 20

Mom. Resolution

Track eff.
- quality < 2
- nhits > 30

Working on rejecting outliers

abs(dpt)<0.50&&quality<2&&nhits>30

h3	
Entries	90
Mean	−0.008435
RMS	0.04161
χ^2 / ndf	11.54 / 17
Constant	4.981 ± 1.350
Mean	−0.001694 ± 0.001275
Sigma	0.007254 ± 0.001921

Timers for Pattern Recognition

```
=============== Timers: ================
Seeding time:                    123.907 sec
    - Seeds Cleanup:             2.23723 sec
Pattern recognition time:        144.796 sec
    - Track Translation time:    57.5193 sec
    - Cluster searching time:    7.30252 sec
        - Encoding time:         0.365767 sec
        - Map iteration:         5.27908 sec
    - Kalman updater time:       52.9921 sec
```

Next

Needed - before May. 22

- Tune the TPC cluster resolution

- Improve good seeding efficiency in Hijing

- Improve robustness - more exception handling

Important but could do later
- Ambiguity resolution
- Iterative tracking
- Memory usage of the full fitting
- Electron reconstruction
- etc.